James Lovelock on **Environmental Ethics**

Lovelock, J., 2016. Gaia: A New Look at Life on Earth. 2nd ed. Oxford: Oxford University Press.

1. Introductory: personal interest in understanding the nature of life began whilst designing instruments capable of detecting life on Mars for the National Aeronautics and Space Administration (NASA). This was a difficult task, because of the diversity of living organisms and the difficulty of defining "life". Notwithstanding this, all known living organisms are entropy reducing; in other words, they resist the dissipation and equal distribution of heat (e.g. the human body, which generates and concentrates heat within it instead of allowing it to disperse). Physicists note that living organisms produce and expel low-grade substances (i.e. waste) during the process of entropy reduction; this insight provided the basis for a life-detecting instrument, because planets with life should have atmospheres that are in disequilibrium due to abundant and volatile low-grade substances. The Gaia hypothesis is that Earth's atmosphere is an extension of its biosphere: a product of living organisms, just like a wasp nest, that could be made uninhabitable by excessive change unless life is given time to adapt.

2. In the beginning: Earth was formed approximately four and a half billion years ago, and the earliest traces of life on Earth were left approximately three billion years ago. Life may have been created by radiation from nuclear elements on Earth's surface (e.g. uranium) and the Sun; however, its continued existence suggests that it began interacting with Earth's atmosphere from an early stage. If life had not, then it would have consumed all of the atmosphere's carbon dioxide, and died as a result of global freezing. Unlike Venus and Mars, Earth's atmosphere has remained stable in composition and temperature since the creation of life; this suggests a dynamic relationship between the atmosphere and the biosphere, which is capable of responding to significant changes. Over the last three billion years, life has avoided burning, freezing, poisoning, and starvation; it is incredibly unlikely that it managed this by blind chance, more likely Earth evolved the capacity for global regulation through the dynamic relationship between atmosphere and biosphere (i.e. Gaia).

3. The recognition of Gaia: Scientific modelling suggests that if Earth's temperature was kept at 15 degrees Celsius, chemical reactions would occur until a near equilibrium state was reached: the atmosphere would contain 98 percent carbon dioxide (not 0.03 percent), one percent nitrogen (not 78 percent), and no oxygen (not 21 percent). Likewise, the oceans would contain 85 percent water and 13 percent salt (not 96 percent water and 3.5 percent salt). Mars exists in a near equilibrium state with trace amounts of oxygen and a large amount of carbon dioxide in the atmosphere. The disequilibrium of Earth's atmosphere, and the living organisms that regulate it, reveals Gaia. The atmosphere and oceans (in their present states) would not last a million years in the absence of living organisms. Comparison with Mars and Venus shows that whilst both have different temperatures, they have very similar atmospheres (overwhelming amounts of carbon dioxide, and trace amounts of oxygen). The contrast between Earth and both Mars and Venus reveals that regulation of Earth's atmosphere occurs on a global scale: this is Gaia's work.

4. Cybernetics: cybernetics is the study of self-regulating systems (e.g. Gaia); those that have aims that they are designed to achieve, and constantly adjust to achieve them. The thermostatic oven is a simple cybernetic system: its aim is to maintain a constant temperature, and it constantly adjusts to achieve this. Human temperature regulation is a more complex example: its aim is to keep the body as close as possible to 37 degrees Celsius. Unlike the thermostatic oven, the body has several mechanisms to regulate temperature (e.g. blood vessel dilation, shivering, sweating), which is why scientists took a long time to understand how it operated. If Gaia has a temperature regulating cybernetic system, it may be difficult to discover, because it must be a complex and extensive global system; however, Earth's relatively narrow temperature range suggests that it exists. The only difference between living organisms and mechanical objects is the complexity of their cybernetic systems; it is likely that Gaia's are complex and varied.

5. The contemporary atmosphere: the disequilibrium of Earth's atmosphere is unique (especially when compared with Mars and Venus), but makes conditions on Earth's surface surprisingly stable: this quality reveals the existence of Gaia. For example, Earth's atmosphere contains enough oxygen (21 percent) to facilitate the flourishing of aerobic (i.e. oxygen consuming) life; however, if it reached 25 percent, all flammable material on Earth would burn uncontrollably. Consequently, the oxygen content of Earth's atmosphere appears to be maintained at an optimum

level. Likewise, the atmosphere contains a large amount of nitrogen, which dilutes its oxygen content and isolates nitrogen from the oceans. If nitrogen in the atmosphere was reduced to its perfect equilibrium state (i.e. nitrate), the oceans would become so salty that almost all living organisms would die. Likewise, carbon dioxide and water vapour appear to be regulated, because they exist in life sustaining quantities. So many mechanisms appear to be involved that it is difficult to describe exactly how Gaia regulates Earth; however, the composition of the atmosphere is so different from scientific modelling of Earth's perfect equilibrium state that regulation must be occurring.

6. The sea: the composition of the oceans also suggests that they are maintained at an optimum level for living organisms. The salt content of the oceans (3.4 percent) has remained stable over the last three billion years; however, it should not have done, because every year continental run-off and tectonic activity add hundreds of megatons of salt to the oceans. Only rare living organisms can survive in environments above six percent salt; the oceans should have exceeded this threshold by now (rendering them largely lifeless) but have not, suggesting they must be regulated. Notwithstanding this, the method of regulation is difficult to identify. It is possible that microscopic living organisms trap salt and transport it to the ocean floor, or that coral reefs are part of a regulatory system for the creation of salt flats; these trap large quantities of salt and prevent it from building up in the oceans in dangerous concentrations. The cycles that involve the oceans are poorly understood: fortunately, human beings have interfered more on land (e.g. agriculture) than they have at sea; however, they must be careful to preserve the oceans given their clear importance to regulatory systems.

7. Gaia and man: the problem of pollution: waste products produced by human beings, like waste products produced by other living organisms, are not necessarily problematic (although they are often considered problematic when viewed from an anthropocentric perspective). They are only concerning when they cause significant changes in cybernetic systems: for example, human beings have increased the sulphur cycle by 100 percent. Disruptions in these cybernetic systems may have global consequences, particularly if the habitats where regulatory systems are likely to be located (e.g. continental shelves (i.e. shallow seas), wetlands) are damaged or destroyed. Very concerning is the prospect of continental shelf farming: for example, clearing kelp forests may reduce methyl iodine gas production to levels that make Earth uninhabitable for human beings. Rainforests also appear to be habitats where many of Gaia's regulatory systems are located; consequently, rainforest fire clearance may have very concerning consequences (including the production of ozone destroying gases). Certain habitats may have a disproportionate regulatory effect on Earth's ability to sustain life in its present forms.

8. Living within Gaia: the Gaia hypothesis perceives human beings as one part of a complex single entity (i.e. Gaia); however, accepts that they have the ability to modify Gaia in unprecedented ways. For example, human beings could impede Gaia's tendency to maintain tolerable living conditions, or destroy Gaia's vital regulatory organs (e.g. rainforests). However, human beings may be able to anticipate the unprecedented modifications they might otherwise make, and prevent them (e.g. by enacting environmental legislation and regulation); consequently, they should be cautious. Human beings are part of Gaia, because all iving organisms have the ability to modify their environments to some extent; however, human beings are different because of both the degree of their modifications and their awareness of them. Human beings cannot abandon technologies without inflicting harm on themselves, but should be more discerning in their choices of technologies. There are no laws for living within Gaia, there are only actions and consequences; however, some actions may have very significant consequences, and human beings should take care to prevent disaster.

9. Epilogue: there is something difficult to describe about the Gaia hypothesis: when Gaia is in harmony, human beings appear to perceive beauty; when Gaia is in discord, human beings appear to perceive ugliness. In childhood, personal experiences of gardening and walking inspired an awareness of symbiosis (i.e. interrelationship) within nature and an appreciation of harmony. It is possible that genetic health is expressed in human beauty, which acts as a proxy for it, whilst Gaian health is expressed in natural beauty, which acts as a proxy for it. In other words, it is possible that human beings are genetically programmed to appreciate natural beauty as a regulatory system for promoting Gaia's health. Most environmentalists perceive human beings as in charge or in control of Earth, which is a nonsensical conclusion from a Gaian perspective: human beings are just one part of a single complex entity. Human beings may be best envisaged as Gaia's nervous system, capable of making Gaia conscious. It is possible that human beings could use their technologies to prevent an asteroid strike or the onset of an ice age to the benefit of Gaia; in time, human beings may be willing to perceive themselves as just one part of a complex whole. However, it is not inevitable that human beings will be the species that continues to manifest Gaia's consciousness